REVIEWS AND COMMENTARY

Contraception, Unintended Pregnancies, and Sexually Transmitted Diseases: Why Isn't a Simple Solution Possible?

Willard Cates, Jr.

As the initial Professor of Epidemiology at The Johns Hopkins University in the 1920s, Wade Hampton Frost played a pivotal role in establishing the science of epidemiology as the basis for public health practice (1). One of Frost's greatest contributions was to contrast the institution's clinical excellence as exemplified by Sir William Osler against a population perspective required for both epidemiologic thinking and public health action. In this regard, Frost's emphasis on both measuring and influencing the aggregate actions of individuals helped distinguish the burgeoning science of epidemiology from the other clinical sciences at Johns Hopkins.

Epidemiology is even more relevant today. Domestically we are dealing with public health downsizing, and globally we are confronting concerns about excessive population growth and the human immunodeficiency virus pandemic. My commentary embellishes on this theme by portraying how a population-level approach to preventing the adverse consequences of human sexuality requires a myriad of imperfect, cumulatively effective, contraceptive methods.

POPULATION-LEVEL PERSPECTIVE OF PUBLIC HEALTH

Risk-exposure relations

Many leaders in public health since Frost have been advocates for aggregate action. In recent years, the late Geoffrey Rose of London again reminded us how prevention strategies should be more concerned with the health of populations than the health of individuals (2). Like any good epidemiologist, Rose began by quantifying the relation between an exposure to a causal agent and the associated risk of disease ensuing from this exposure. He demonstrated how these risk-exposure associations can take several shapes.

For example, one risk-exposure relation defines a "threshold effect" (figure 1). In this case, the ongoing exposure has no measurable adverse effects until it reaches a certain high level, beyond which the risk increases rapidly. In the clinical world, this threshold effect occurs with intraocular pressure, which can vary over a wide, so-called normal range without causing any apparent pathology. However, when intraocular pressure exceeds a critical level, the incidence of glaucoma rapidly rises. Likewise, threshold exposure-risk effects can occur when a low red blood cell count causes noticeable symptoms only below a "normal" threshold, or when blood alcohol levels above a certain threshold are associated with markedly higher rates of automobile crashes.

Another type of risk-exposure relation can be construed in a linear manner (figure 2). With a linear dose-effect relation, the risk increases directly as exposure increases. Therefore, any level of exposure should be regarded as hazardous, with the excess of adverse effects being directly proportional to the dose received. The cigarette smoking-lung cancer association represents our prototypic linear relation. Another example is the effect of radiation exposure on the
occurrence of neoplasia, which rises progressively over the whole range of radiation exposures. This concept of a linear risk-exposure relation has major public health implications. It means that the ideal prevention policy would be to totally eliminate all avoidable exposure.

The U-shaped relation between risk and exposure is the most complex of Rose’s models (figure 3). With this relation, a central band exists in which exposure causes little concern, but at either end of the exposure spectrum, risks increase. For example, both very small and very large infants have higher neonatal mortality rates than do those of more “normal” birth weights. Similarly, neither excessively low nor excessively high blood pressure is desirable, since both lead to adverse outcomes.

Finally, an “inverted U-shaped” curve characterizes some conditions (figure 4). For example, the incidence of sexually transmitted diseases, particularly chlamydial infection, is related to age. Levels of incident sexually transmitted disease are nonexistent until sexual activity begins, peak in the adolescent/young adult years, and then taper off thereafter. Similar curves are typical for other adverse reproductive health conditions that are related to either sexual activity or fecundability.

Population-based prevention strategies

In brief, Rose’s thesis is elegantly simple (2): prevention policies that focus on high risk individuals may offer substantial benefits to those individuals, but their potential impact on the total burden of disease in the population is frequently disappointing (2). This is because most cases of disease arise among the many who are at lower risk rather than among the few who are at high risk.
Contraception, Unintended Pregnancies, and Diseases

Figure 4. An inverted U-shaped relation of risk to exposure.

Figure 5. The effect of moving the population norm to lower levels of exposure and risk (source: G. Rose. The strategy of preventive medicine. Oxford, England: Oxford University Press, 1992).

...in the figure. Nearly everyone now enjoys a slightly lower risk than before, and by repeating the previous calculations, we can obtain the new total of attributable cases. For example, an overall 10 percent lowering of smoking levels can achieve a 50 percent reduction in lung cancer. Alternatively, we can consider a 5 percent reduction in blood pressure to gain a 30 percent decrease in stroke. Compare this to a "high-risk" campaign targeting individuals where, if all cases of hypertension with a diastolic blood pressure more than 100 mmHg were detected and treated (which would cut in half their individual risk), the campaign would produce only a 15 percent reduction in the total number of strokes among the entire population.

These benefits of a populationwide, generalized lowering of risk are produced in two ways. The first results from shifting high risk individuals out of the danger zones. Yet, the second and more robust reason is that the larger number of people exposed to a small risk generate much more disease than the few exposed to a higher level of risk.

Contraception and Unintended Pregnancy/Sexually Transmitted Diseases

Reproductive life stages

These elegant, yet simple, concepts of Geoffrey Rose underlie our approaches to a crucial public health issue of our times, namely, the relation between the exposure category of contraceptive choices and the specific outcomes we are trying to prevent, namely, unintended pregnancies and sexually transmitted infections. In epidemiologic terms, we can present this as a "natural history" of sexual and reproductive events in a population of females (figure 6), characterized by different intervals of biologic and behavioral risk (3). Regarding pregnancy, for most American women, a relatively short interval exists—stages 3 and 4 in the figure—when any pregnancies are truly intended. Based on data from the most recent National Survey of Family Growth, in 1988, this accounted for about 15 percent of a woman’s reproductive life (3). However, women are exposed to a much longer interval when they are sexually active, yet do not wish to get pregnant. Regarding infection, throughout all the reproductive life stages, any sexually transmitted diseases (especially human immunodeficiency virus) would never be intended. Thus, during nearly all of one’s reproductive life, the person is at risk of the two key adverse consequences of sexuality—unintended pregnancy and sexually transmitted disease.

To prevent these outcomes, three strategies are possible. The first is to avoid vaginal intercourse altogether, usually referred to as abstinence. The second is to have coitus with an infertile, uninfected sex partner. When pregnancy is desired to preserve the species, an alternate strategy would be to have vaginal intercourse with a fertile, though uninfected partner. Realizing that this degree of partner knowledge is difficult at best, the third strategy for sexually active persons is to assume the partner is both fertile and infected and, thus, use contraceptive measures to protect against the undesired outcomes.

Contraceptive effects on pregnancy and sexually transmitted disease

Our currently available contraceptives differentially affect pregnancy and sexually transmitted disease risks. Regarding pregnancy, modern contraceptives are frequently portrayed as having both an ideal and an actual use effectiveness (4). Moreover, the actual use effectiveness depends on a variety of factors that pro-
vide a large range of effectiveness in preventing unintended pregnancies (figure 7). For example, again based on National Survey of Family Growth data, young, unmarried persons generally have higher contraceptive failure rates than older, married individuals (5).

For sexually transmitted infections, our knowledge of the effectiveness of the different contraceptives on sexually transmitted disease is less certain, having a wider range of both protective and harmful influences than on pregnancy (table 1). For example, condoms protect against both bacterial and viral sexually transmitted disease (6, 7). Spermicides prevent infection with chlamydia and gonorrhea, but their role in preventing viral infections (including human immunodeficiency virus) has not been scientifically established (8). Diaphragms (usually used with spermicides) provide a mechanical barrier against cervical infection, but they have been associated with vaginal and bladder infections (9). Oral contraceptives are associated with an increased detection of cervical chlamydial infection but protect against symptomatic pelvic inflammatory disease (10). The role of hormonal contraception in potentiating or protecting against the transmission of human immunodeficiency virus (possibly through the biologic mechanism of cervical ectopy) remains to be

![FIGURE 6. Key points in a woman's reproductive life (source: J. D. Forrest, Obstet Gynecol 1993;82:10511) (3)]](image_url)

![FIGURE 7. Contraceptive failure rates of perfect versus typical use (adapted from E. F. Jones and J. D. Forrest Fam Plann Perspect 1992;24:12-19) (5) IUDs, Intrauterine devices. Depo-Provera (The Upjohn Company, Kalamazoo, Michigan).]](image_url)
established (11). Finally, intrauterine devices are associated with pelvic inflammatory disease, especially in the first month after insertion (12).

Unfortunately, we therefore are faced with a contraceptive "trade-off" dilemma (6). Those contraceptives with the best record of preventing pregnancy have the worst record for preventing sexually transmitted infections. Some authorities have advocated the use of two methods—one to prevent pregnancy and the other to prevent sexually transmitted disease/human immunodeficiency virus (13, 14). Dual method use would provide a reinforcing effect on both of these adverse outcomes. While this sounds logical in the ideal, studies have shown a potential for contraceptive "antisynergy" in practice (table 2). Namely, if couples are using an effective method for preventing pregnancy, they may be less likely to use a second method with a good record of preventing sexually transmitted diseases.

Studies on dual method use are limited and have focused on the use of the male condom added to other primary methods of contraception (15–24). In general, where participants were using primary methods other than the condom, the more effective the primary contraceptive method was in preventing pregnancy, the lower the level of consistent use of the male condom (table 2). For example, in Baltimore and Philadelphia, respectively, 6 percent and 12 percent of women who were sterilized used condoms consistently to prevent sexually transmitted diseases (15, 16). In Philadelphia, Norplant (Wyeth-Ayerst, Philadelphia, Pennsylvania) users reported lower levels of condom use than did those using oral contraceptives (19). However, among oral contraceptive users, studies conducted in the 1990s have found higher levels of self-reported consistent condom use than did those conducted in the 1980s (13, 19–22).

With spermicides as the primary contraceptive method, the percentage of consistent condom users varied dramatically among three countries (table 2). This indicates that factors other than the method itself affect levels of concurrent condom use (23). The percentages of populations using male condoms alone for both primary contraception and sexually transmitted diseases

Table 1. Effects of contraceptives on bacterial and viral sexually transmitted disease*

<table>
<thead>
<tr>
<th>Contraceptive methods</th>
<th>Bacterial STD†</th>
<th>Viral STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condoms</td>
<td>Protective</td>
<td>Protective</td>
</tr>
<tr>
<td>Spermicides</td>
<td>Protective against cervical gonorrhea and chlamydia</td>
<td>Undetermined in vivo</td>
</tr>
<tr>
<td>Diaphragms</td>
<td>Protective against cervical infection; associated with vaginal anaerobic overgrowth</td>
<td>Protective against cervical infection</td>
</tr>
<tr>
<td>Hormonal contraception</td>
<td>Associated with increased cervical chlamydia; protective against symptomatic PID†</td>
<td>Not protective</td>
</tr>
<tr>
<td>IUD†</td>
<td>Associated with PID in the first month after insertion</td>
<td>Not protective</td>
</tr>
<tr>
<td>Natural family planning</td>
<td>Not protective</td>
<td>Not protective</td>
</tr>
</tbody>
</table>

† STD, sexually transmitted disease; PID, pelvic inflammatory disease; IUD, intrauterine device.

Table 2. Studies of condom use in conjunction with other contraceptive methods

<table>
<thead>
<tr>
<th>Primary contraceptive by study location</th>
<th>% reporting consistent condom use</th>
<th>Reference no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sterilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baltimore, Maryland</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Philadelphia, Pennsylvania</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Norplant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Houston, Texas</td>
<td>21</td>
<td>17</td>
</tr>
<tr>
<td>Atlanta, Georgia</td>
<td>35</td>
<td>18</td>
</tr>
<tr>
<td>Philadelphia, Pennsylvania</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>Oral contraceptives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baltimore, Maryland, 1988</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>Baltimore, Maryland, 1992</td>
<td>38</td>
<td>21</td>
</tr>
<tr>
<td>United States, 1988</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>United States, 1991</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>United States, 1994</td>
<td>46</td>
<td>13</td>
</tr>
<tr>
<td>Philadelphia, Pennsylvania</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td>Spermicides</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>75</td>
<td>23</td>
</tr>
<tr>
<td>Kenya</td>
<td>43</td>
<td>23</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>Condoms only (multiple studies)</td>
<td>25–90</td>
<td>24</td>
</tr>
</tbody>
</table>

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disease prophylaxis range from 25 percent to 95 percent (24). Studies that examine the use of the female condom, diaphragm, and/or spermicides in conjunction with long-term methods are needed to help clarify this issue. More research is also needed on the patterns of dual method use with different sex partners. If an individual uses one method with a monogamous partner and adds condoms with other partners, this might effectively reduce risk, even if dual method use is not consistent in all encounters.

The use of one method for dual purposes is also possible. The male condom, if used "perfectly," namely, consistently and correctly, has the best record of any single contraceptive method for preventing both unintended pregnancy and sexually transmitted diseases (24). However, the male condom requires the man to agree to its use and, thus, is not a female-controlled method. The female condom, now approved for general use, has not gained wide acceptance among regular contraceptive users. Thus, research into female-controlled methods is a high priority (25).

**REPRODUCTIVE HEALTH POPULATION STRATEGIES**

What type of population-level strategy would provide the best protection against both unplanned pregnancy and sexually transmitted disease? Using the Rose model described earlier, a completely "risk-free" relation of risk to exposure could be either to have no vaginal intercourse at all, namely, to be sexually abstinent, or to have unprotected sex with an uninfected or infertile partner (figure 8). When pregnancy would be desired, sex with an uninfected, fertile partner would allow species survival.

On the other hand, if unprotected sex occurs with an infected or fertile partner, a more convex exponential shape of the risk-exposure relation is evident (figure 9). This happens because most of the risk of becoming infected or pregnant occurs in the first several acts of intercourse, after which immunologic or other host factors probably decrease the marginal chances of infection or pregnancy. The exact shapes of the convex curves would differ between unintended pregnancy and sexually transmitted disease (as well as among specific sexually transmitted diseases) because the risks per given unprotected coital events vary. However, the concept is identical.

If one uses barrier protection with an infected partner, the shape becomes concave rather than convex (figure 10). The risk increases only gradually over time as populations incur the small, but measurable, cumulative failures of imperfect barrier methods.

Using a public health model, sexual abstinence will prevent all of the convex exponential risk of unprotected sex. The area under the curve demonstrates the amount of protection that abstinence provides (figure 11). However, intercourse using barrier methods of contraception, while not perfect, also provides a large measure of protection against the risk of sexually transmitted disease or unplanned pregnancy. An elliptical “protective” shape occurs representing the difference between the convex curve of unprotected sex and the concave curve of protected sex (figure 12). When both strategies are plotted together, the estimated area under the curve of protected sex actually reduces some 70 percent of the total risk between unprotected sex and complete sexual abstinence (figure 13).

Conceptually, preventing sexually transmitted diseases at the population level may be "easier" than preventing unintended pregnancy. In the general population, a smaller proportion of persons are infected and thus able to transmit the infection versus a much larger proportion who are fecund and thus able to "transmit" pregnancy (26). Consequently, for sexually transmitted diseases, prevention strategies targeting
high risk “core populations” can efficiently act as environmental interventions affecting transmission within the societal “bell-shaped” general population

(27). Anything that prevents sexually transmitted diseases in high risk populations (e.g., increased condom use by sex workers (28, 29)) simultaneously reduces exposure for the general population. At the community level, lowering sexually transmitted disease prevalence within particular sociosexual networks serves to reduce exposure overall.

Unfortunately, for persons choosing to be sexually active with probably fertile and possibly infected partners (which is the vast majority of our reproductive age population), none of the contraceptives available provides perfect, simple solutions. Therefore, an absolutist approach to solving this situation is impossible (30). Rather, we need a spectrum of imperfect, yet cumulatively effective, solutions that build on each other to move the social norm toward the lowest level of risk for any sexual exposure. Because no one contraceptive in and of itself provides complete protection against either unintended pregnancy or sexually transmitted disease, we will need as wide a mix of contraceptive choice as possible to achieve the maximum movement of the “bell-shaped curve” toward safer sexual behaviors.

To summarize:

1. During nearly all our reproductive lives we are at risk of unintended pregnancy and sexually transmitted disease.
2. Using actual effectiveness measures, no one current contraceptive provides good protection against both unplanned pregnancy and sexually transmitted disease.
3. Among different populations, a wide variation exists in the level of contraceptive effectiveness against both of these outcomes.
4. Because condoms require male cooperation, we need better female-controlled methods.
5. Thus, no simple solutions are yet possible.

However, this should stimulate rather than depress us. Both Wade Hampton Frost and Geoffrey Rose realized the strength of epidemiology and of aggregate reasoning applied to populations. Our science of epidemiology allows us not only to define risk but also to measure our success at moving the population norm continually toward our goal of increasingly safer behaviors.

REFERENCES


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